Welcome

My name is ############

The major topic of this presentation is the changes to the provisions for lateral load resistance in Part 9 (Housing and Small Buidlings) in the National Building Code of Canada, and will focus primarily on NBC Part 9 houses.

Introduction

- Presentation is part of a series on the 2010 National Model Construction Codes
- Model codes developed by Canadian Commission on Building and Fire Codes
- These codes must be adopted by provincial/territorial authorities to become law

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This presentation is part of a series of 13
on the 2010 National Model Construction Codes.

It is important to note that the model codes, which are developed
by the Canadian Commission on Building and Fire Codes,
must be adopted by provincial/territorial authorities to become law.

This may mean that code requirements enacted by legislation within your province or territory might differ from what is presented here.

Please check with your local authority.

Overview

- General Background
- Technical Principles
- Summary of Basic Code Change Proposals
- Trade-Off Code Change Proposals

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This presentation is divided into 4 sections, dealing with

- general background
- the technical principles behind structural behaviour under lateral loads
- a summary of the basic code changes
- a discussion of the trade-off provisions

Part 9 Lateral Loads

- General Background
- Technical Principles
- Summary of Basic Code Change Proposals
- Trade-Off Code Change Proposals

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First, let's discuss the general background and why this is being addressed.

General Issue

- Conventional house construction
  - Exterior and interior walls
  - Redundant paths of travel

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The previous editions of Part 9 were based on traditional construction, that is having

- relatively large portions of exterior walls intact, and
- interior rooms with interior walls

These are the lateral load resisting elements and, in the traditional type of construction, result in redundancy in structure, i.e. alternate paths of travel for loads.

General Issue – cont'd

- Narrow lots, panoramic views
  - Small wall area in front
- Open concept
  - Few interior walls

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Recent trends are that, in built up areas, lot lines are reduced from the typical 50 or 60' to 35 or 30'. This results in the front face being almost completely consumed by the garage door(s), person door and a picture window.

In addition, houses constructed on scenic lots with panoramic views very often have exterior walls with many large windows.

In both of these situations, the amount of exterior wall that can resist lateral loads is significantly reduced.

There is also a trend to open concept design, which means less interior walls to resist lateral loads.

In summary, the basis of the Part 9 provisions that were established for traditional construction may no longer be correct for new trends.

Background

- 2005 NBC Part 9 does not contain explicit requirements for resistance against lateral loads
- Proposed code changes for 2005 NBC deferred
- Province requested more time
- Lateral Load Task Group formed
  - Reviewed material from last code cycle, CWC Guide, consultant reports, recent research

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There were no explicit provisions in NBC 2005 for system to resist lateral loads.

Provisions were proposed for NBC 2005 but were deferred due to concerns raised.

A Task Group on Lateral Loads was formed to develop provisions for NBC 2010 taking into account

- prior proposed provisions
- consultants reports on concerns that were raised
- developments in Canadian Wood Council guide
- latest research

Part 9 Lateral Loads

- General Background
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- Trade-Off Code Change Proposals

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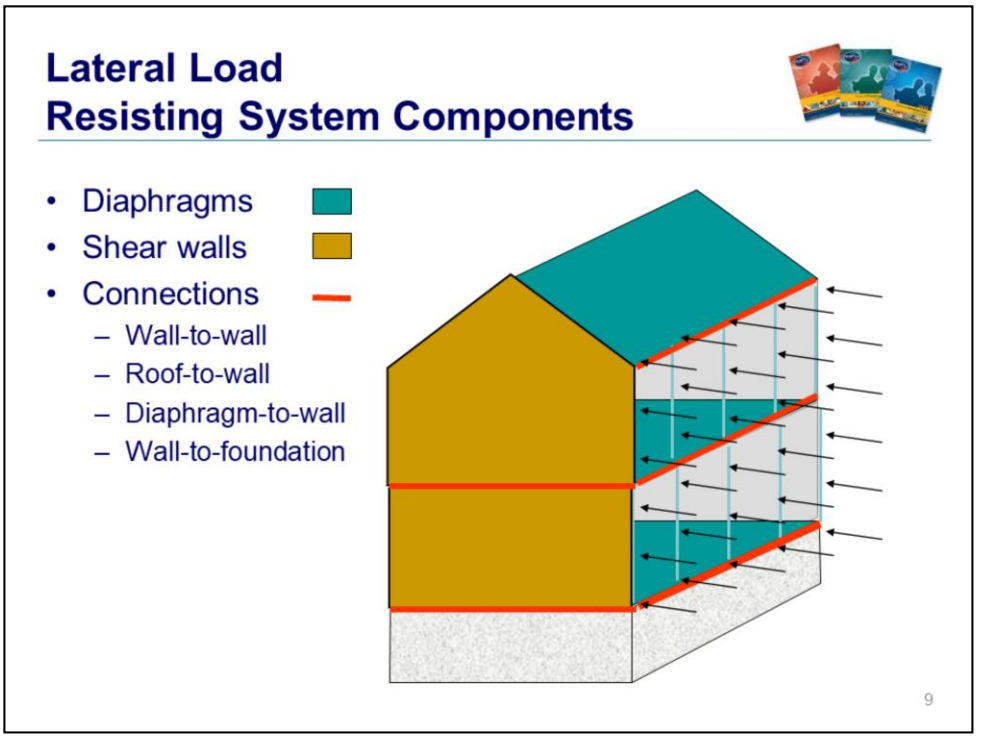
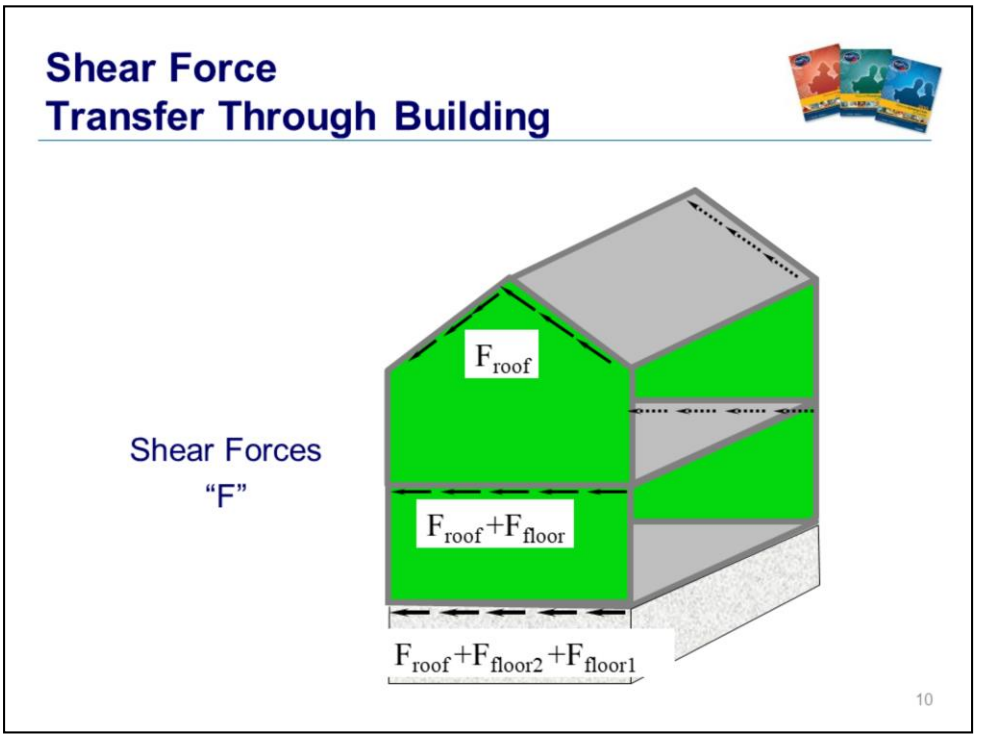
Now, we'll review the technical principles behind the lateral loads and structural behaviour.



The basic structural principles are as follows:

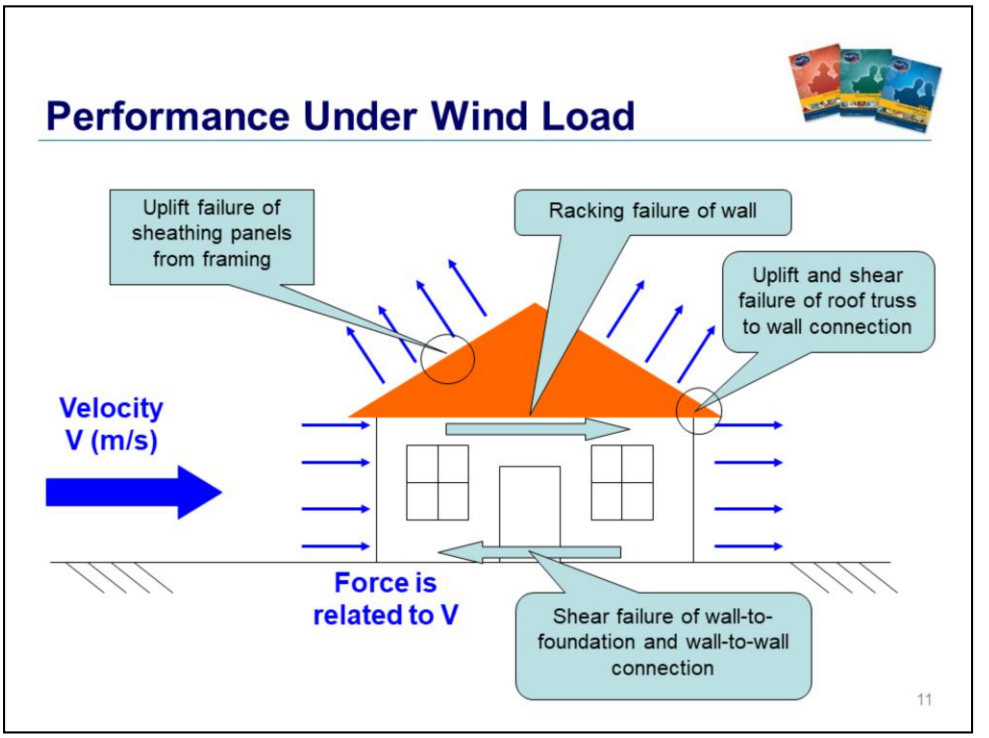
Lateral loads are transferred horizontally through diaphragms, i.e. roofs and floors to the vertical elements that resist the loads, i.e. shear walls or vertical bracing systems.
The loads are then transferred to the foundation.

The connections at each point, roof and floor to wall, wall to wall, and wall to foundation, is where transfer of loads occurs and is critical.



The lateral load is typically transferred from the top of the structure to the bottom as follows:

- the roof diaphragm and floor diaphragm transfer horizontal loads to the supporting walls or braces
- the upper vertical resisting elements, i.e. shear walls or braced walls, transfer the loads to the walls below
- the loads in the walls is additive from top to bottom
- finally the loads are transferred to the foundation



We will now review performance under wind load.

[CLICK]

Wind force is related to wind velocity, and is actually proportional to square of velocity.
It generates pressure in the windward walls and suction in the leeward walls.

On the roof, it typically results in an uplift force, but this is dependant on the roof slope.

[CLICK]

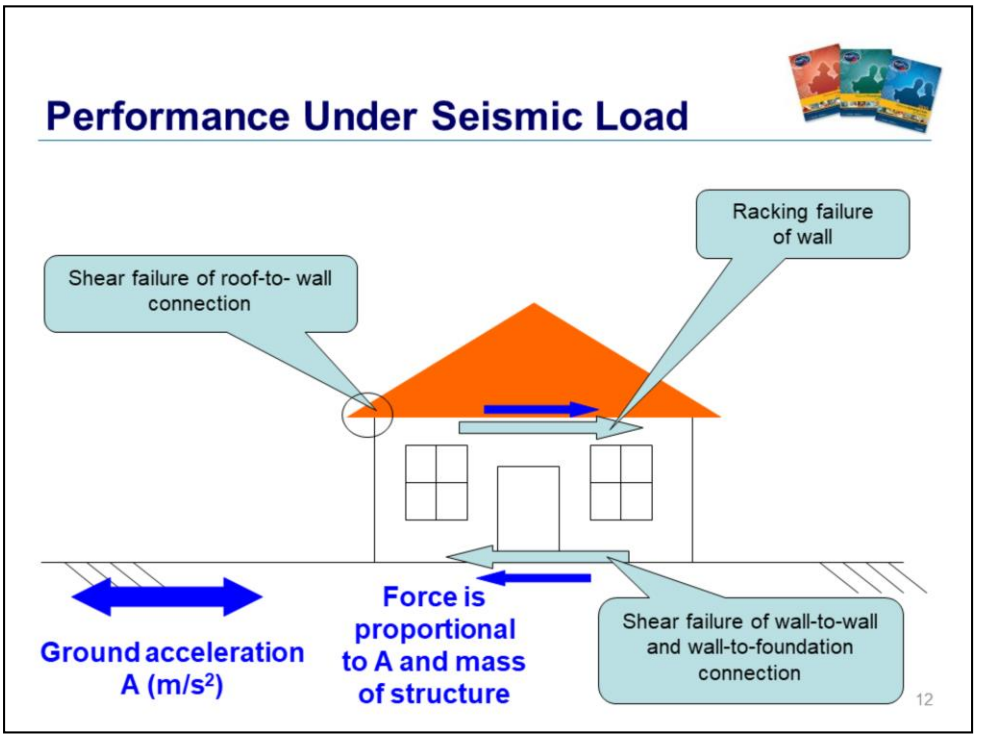
The potential failure mechanisms are

•uplift of the roof sheathing,

•connection failure of the roof to wall

•racking of the wall

•connection failure of the wall to foundation



The performance under seismic load is as follows:

[CLICK]

Earthquake is a ground movement that generates a response in the structure, i.e. it generates a load at each floor and roof.

The load is proportional to magnitude of the earthquake and to the mass of the building.

[CLICK]

The potential failure mechanisms are

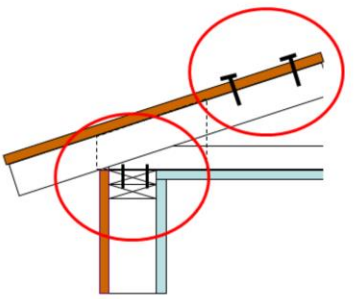
•connection failure of the roof or floor to wall

•racking of the wall

•connection failure of the wall to foundation

Potential Failure Locations

Roof-to-wall connection
and uplift of roof sheathing



Racking failure

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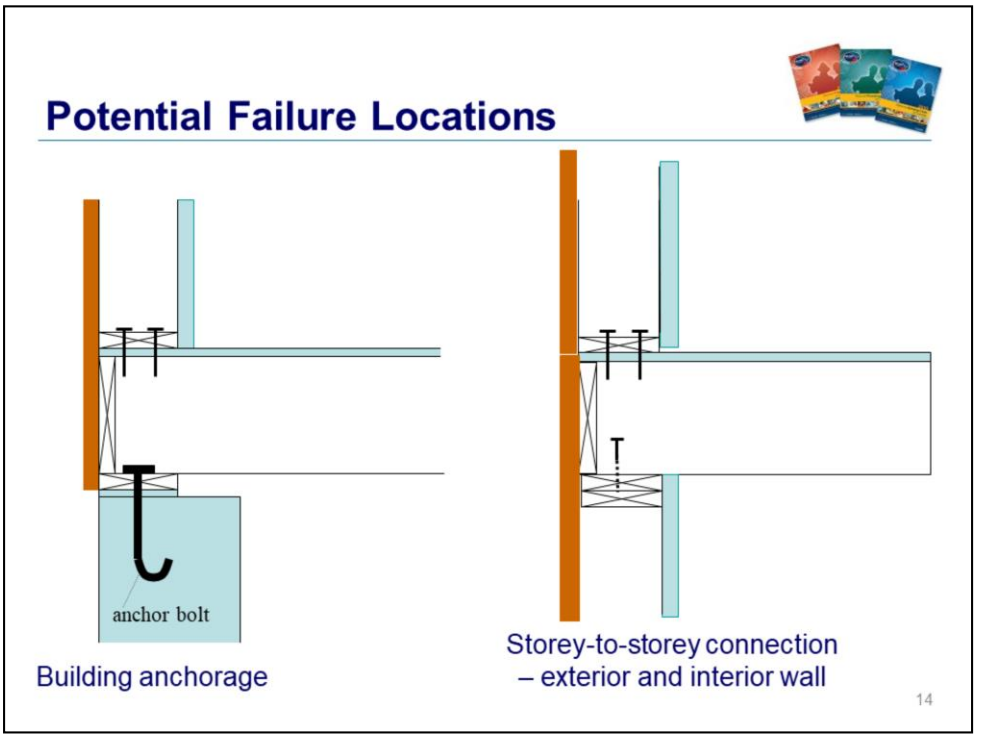
Here you see more examples of the potential failure mechanisms.

The roof-to-wall connection is critical. Uplift of the roof sheathing is related to wind only.

The structure in this photo has failed by racking.



And again, a potential failure location is the wall to wall and wall to foundation connection.

Part 9 Lateral Loads

- General Background
- Technical Principles
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- Trade-Off Code Change Proposals

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Now, we'll focus on the basic prescriptive code changes to address lateral load resistance of Part 9 buildings.

Categories of Wind and Seismic

Category	Wind	Seismic – light	Seismic – heavy	Requirement
	1 in 50 yr hourly wind press, kPa	Spectral response acceleration	Spectral response acceleration	
Low	HWP < 0.8	$S_a(0.2) \leq 0.7$	$S_a(0.2) \leq 0.7$	Same as 2005 NBC
High	0.8 ≤ HWP <1.2	$0.7 < S_a(0.2) \leq 1.2$	$0.7 < S_a(0.2) \leq 1.1$	Requirements in new Subsection 9.23.13.
Extreme	HWP ≥ 1.2	$S_a(0.2) > 1.2$	$S_a(0.2) > 1.1$	Part 4 or accepted practice

$S_a(0.2)$ – Spectral Acceleration at 0.2 seconds
HWP – Hourly Wind Pressure (1-in-50 year return)

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In order to develop technical requirements, limits on applicability of Part 9 had to be set.

The limiting parameters were based on

•Wind, that is the 1-in-50 year pressure values from the climatic tables, and

•earthquake, that is the spectral acceleration values at 0.2 seconds. This is the period that is generally compatible with houses , i.e. short period structures.

Three categories of lateral loads have been set

Low, High, and Extreme

For earthquake, because earthquake loads are proportional to the mass of the structure, a distinction between heavy and light construction was made. Heavy construction is defined as having a tile roof or concrete floor topping. For these buildings, the trigger limits for application of the provisions are lower.

Compliance Options

		HWP		
		0.00 kPa	0.80 kPa	1.20 kPa
$S_a(0.2)$	0.095 0.70	Same as 2005 NBC	New 9.23.13	NBC Part 4 or CWC Guide
	(1.10*) 1.20	New 9.23.13.	New 9.23.13.	NBC Part 4 or CWC Guide
		NBC Part 4 or CWC Guide	NBC Part 4 or CWC Guide	NBC Part 4 or CWC Guide
* heavy construction				

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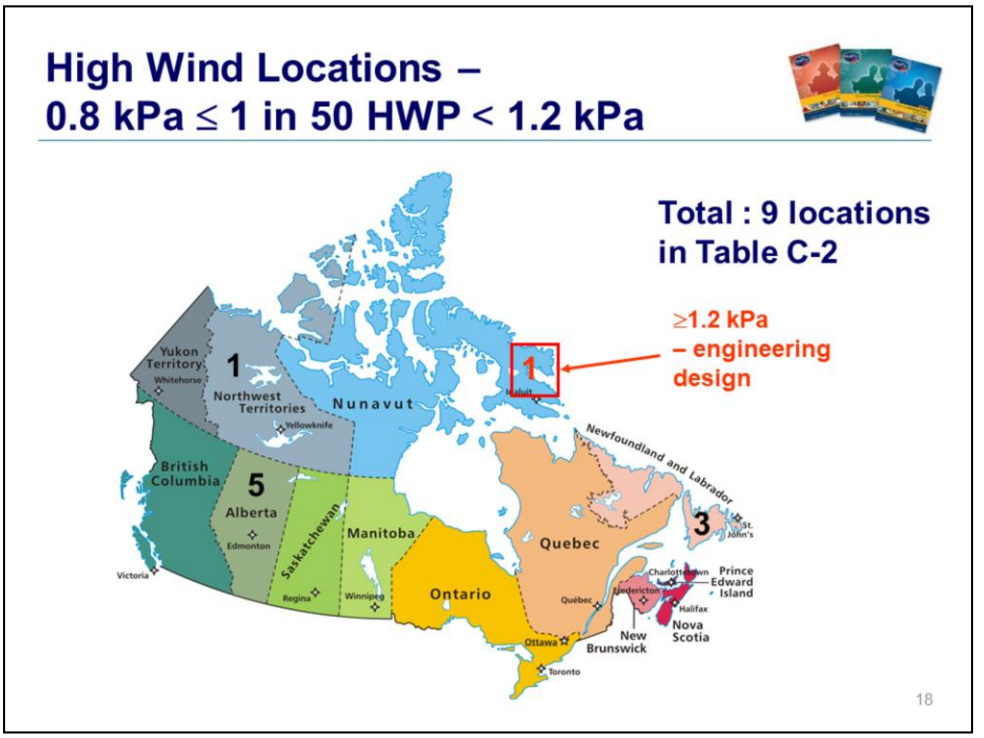
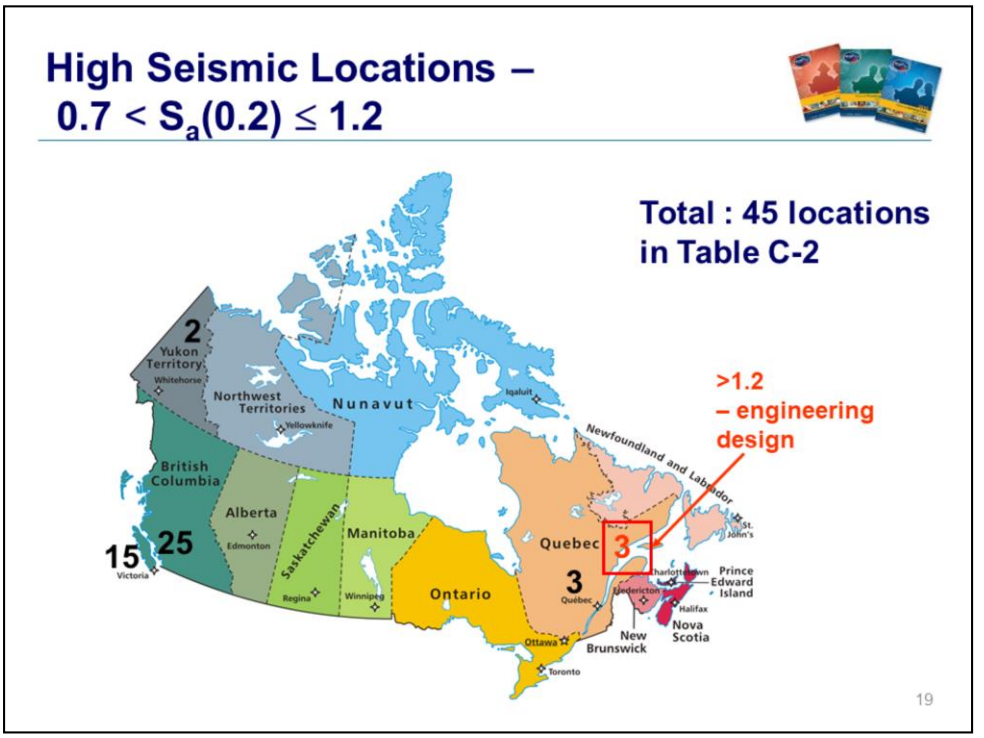
The Low lateral load category is defined as having wind less than 0.8 kPa (125 km/hr) **and** earthquake less than or equal to 0.7. For these situations, the provisions are virtually unchanged from the NBC 2005.

To qualify for the Extreme category, either the wind is greater than or equal to 1.2 kPa (155 km/hr) **or** earthquake is greater than 1.2. For this class, the building must be designed to either Part 4 or the Canadian Wood Council Guide.

In the High lateral load category, either wind or earthquake is higher than the limits of the Low category, but neither higher than Extreme limits. These cases can use the new lateral load provisions in Part 9.



Here you see the impact of the categorization across the country due to wind. Of the 680 or so entries in Table C-2 of the NBC, 9 locations will be required to design to the new provisions in NBC Part 9, and 1 will fall out of the scope of Part 9 and require design to NBC Part 4 or the Canadian Wood Council guide.



And here you see the impact of the categorization across the country due to earthquake. 45 locations, primarily in British Columbia, will be required to design to the new provisions in NBC Part 9, and 3 (in Quebec) will fall out of the scope of Part 9 and require design to NBC Part 4 or the Canadian Wood Council guide.

New Subsection

- Bracing to resist lateral loads due to wind and earthquake
  - *Braced wall panels* aligned in vertical *braced wall bands*

Braced wall panel:
Portion of a wood-frame wall where bracing, sheathing, cladding or interior finish is designed and installed to provide required resistance to lateral loads due to wind or earthquake

Braced wall band:
Imaginary continuous straight band extending vertically and horizontally through the *building* or part of the *building*, within which *braced wall panels* are constructed

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New concept of a braced wall band was developed.

A braced wall band is a vertical plane extending through the height of the building and across its width or depth.

It contains braced wall panels, which are individual elements that actually do the job of resisting the lateral loads.

Definitions for both braced wall band and braced wall panel have been established as shown.

New Subsection – General Requirements

- Requirements given for
  - Alignment of *braced wall panels*
  - Materials used to construct *braced wall panels*
  - Spacing and dimensions of *braced wall panels* and *braced wall bands*

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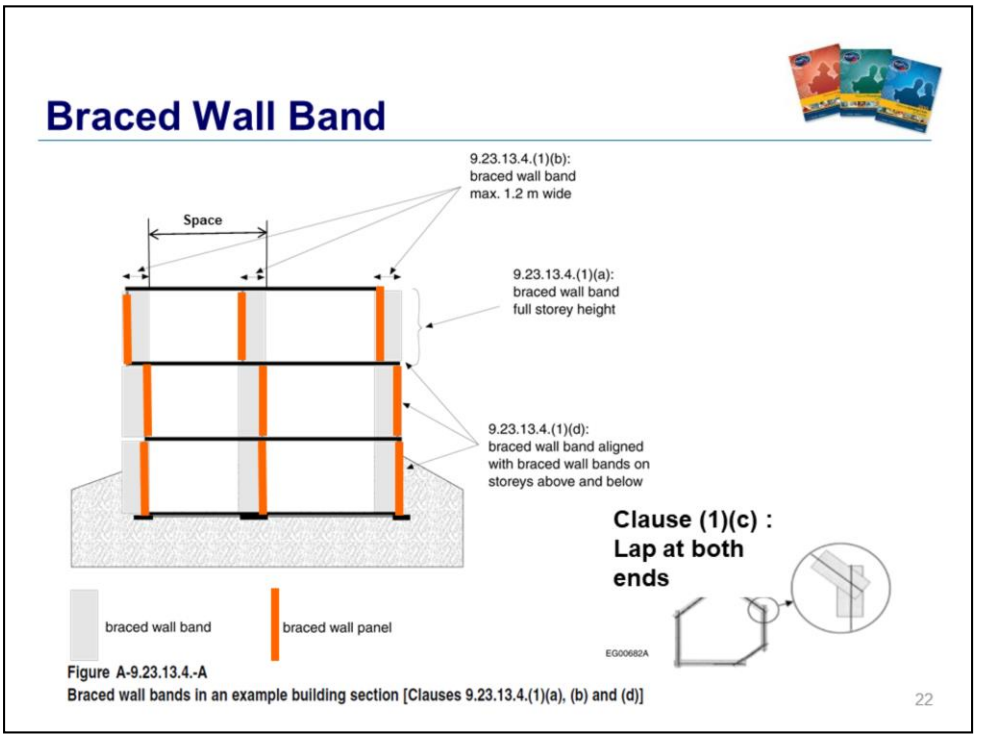
The new provisions set specific criteria and limits for

- the alignment of braced wall panels
- the materials from which the braced wall panels can be constructed
- the spacing and dimensions of the braced wall bands and braced wall panels.



The general concept behind braced wall bands with braced wall panels is the vertical alignment of a band and panels within band, with an allowed band width of 1.2 m. So braced wall panels can be offset a maximum of 0.6 m on either side of the centre line of a braced wall band and still be in that braced wall band.

Braced wall bands must intersect with other braced wall bands at their ends.

Braced Wall Panel Materials

- On exterior walls:
  - Plywood, oriented strandboard (OSB) or diagonal lumber sheathing
- On interior walls:
  - Required interior braced wall panels shall be sheathed or finished on both sides
  - Gypsum board interior finish allowed
  - Plywood, OSB or diagonal lumber sheathing within any 15 m interval

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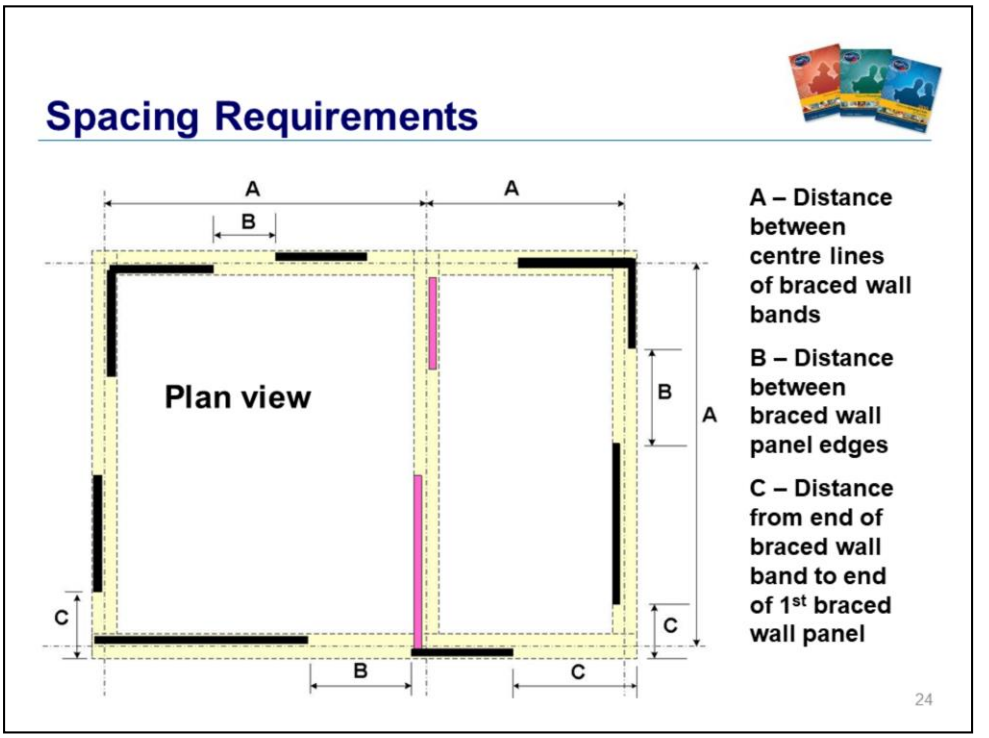
The NBC 2010 regulates the construction materials used in braced wall panels.

Braced wall panels in exterior wall must be constructed of wood-based material, that is sheathed with either plywood or oriented strandboard, or has diagonal lumber to act as a brace.

With some constraints that will be discussed in later slides, braced wall panels in interior walls can be sheathed with gypsum board or constructed of wood-based material as per the exterior braced wall panels.

For the purpose of this presentation, I would like to define a "strong wall" as having wall panels constructed of wood-based material, that is, not using gypsum board as the sheathing.

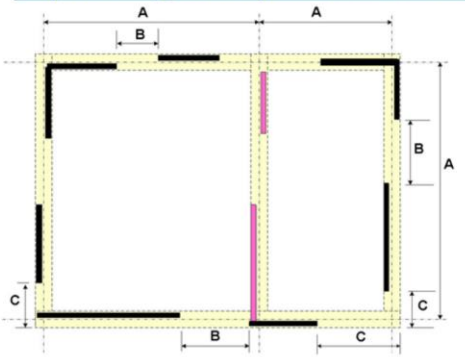
At intervals of not more than 15 m, the required braced wall bands must be constructed as strong walls.



Now let's look at the spacing and dimension provisions for braced wall bands and panels.

This simplified house plan will be used to demonstrate the requirements.

Spacing Requirements



A – Maximum distance between centre lines of adjacent braced wall bands

	$0.70 < S_a(0.2) < 1.0$	$1.0 \leq S_a(0.2) \leq 1.2$ or $0.80 \leq HWP < 1.2$ kPa
A max.	10.6 m	7.6 m

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First, we'll discuss the spacing of the braced wall band centre lines

- it depends on the seismicity and wind of the location

- for low wind areas where earthquake is less than 1.0, the maximum spacing of braced wall bands is 10.6 m

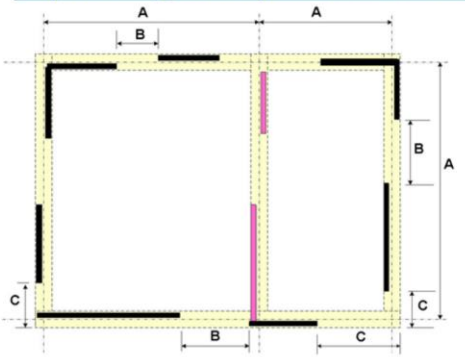
- for low wind areas where earthquake is greater than or equal to 1.0 but less than or equal 1.2, the maximum spacing of braced wall bands is 7.6 m

- for any high wind area where the earthquake is less than or equal to 1.2, the maximum spacing of braced wall bands is 7.6 m

This is "A" in the figure.

Note that at maximum 15 m spacings, there must be a strong wall.

Spacing Requirements



B – Maximum distance between ends of adjacent required braced wall panels

	$0.70 < S_a(0.2) < 1.0$	$1.0 \leq S_a(0.2) \leq 1.2$ or $0.80 \leq HWP < 1.2$ kPa
B max.	6.4 m	6.4 m

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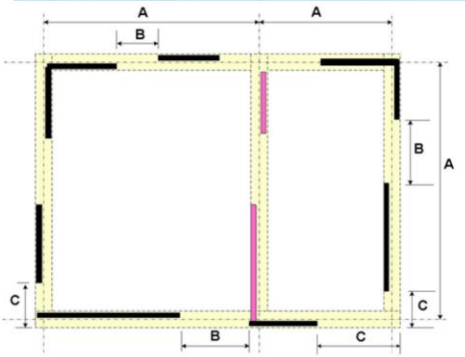
The maximum distance between the ends of the braced wall panels in a braced wall band is 6.4 m. This is "B" in the figure.

Spacing Requirements



C – Maximum distance from end of braced wall band to edge of required braced wall panel

	$0.70 < S_a(0.2) < 1.0$	$1.0 \leq S_a(0.2) \leq 1.2$ or $0.80 \leq HWP < 1.2$ kPa
C max.	2.4 m	2.4 m

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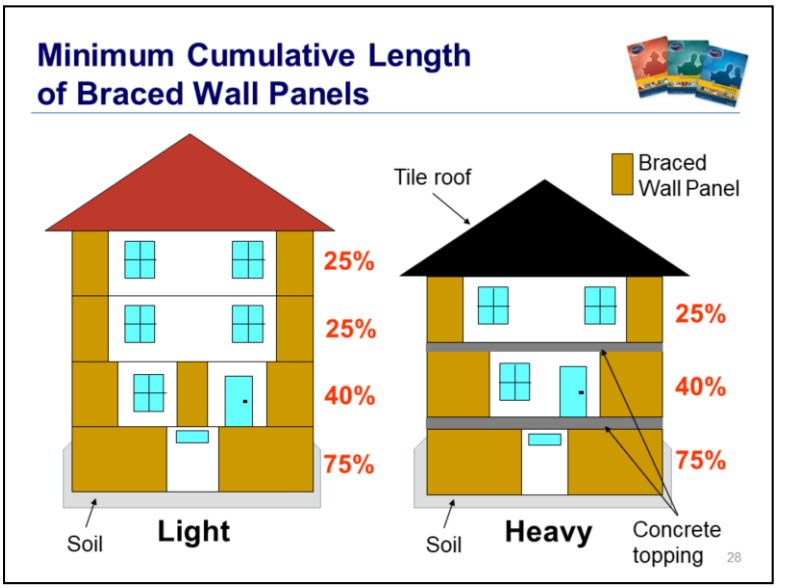
The maximum distance between the ends of braced wall panels in a braced wall band and the outer edge of the intersecting braced wall band is 2.4 m. This is "C" in the figure.



The sum of the lengths of braced wall panels in all individual braced wall bands is as follows:

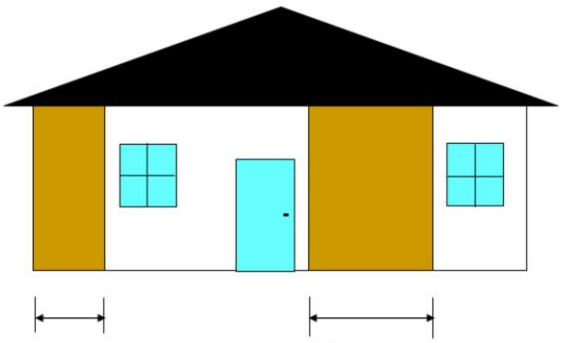
For light construction

- when they support no more than one floor, they need to be no less than 25% of the total wall length
- when they support no more than 2 floors, they need to be no less than 40% of the total wall length
- when they support no more than 3 floors, they need to be no less than 75% of the total wall length.

For heavy construction

- when they do not support a floor, they need to be no less than 25% of the total wall length
- when they support no more than one floor, they need to be no less than 40% of the total wall length
- when they support no more than 2 floors, they need to be no less than 75% of the total wall length
- when they support 3 floors, they must be designed to NBC Part 4 or to the Canadian Wood Council Guide.

Minimum Length of Individual Braced Wall Panels



600 mm minimum length when connecting to intersecting braced wall panel

750 mm minimum length, otherwise

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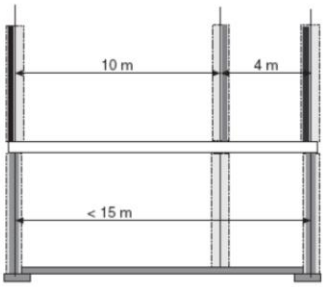
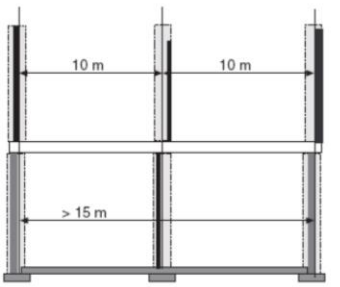
The minimum length of braced wall panels is 750 mm, except that they may be reduced to 600 mm at the ends of the bands where they connect to an intersecting braced wall panel

Relaxation of Bracing Requirement (1) – Basement and Crawl Space

- Max. distance between braced wall bands, and between braced wall band and foundation wall in basement / crawl space is 15 m



braced wall panels not required in braced wall band in basement

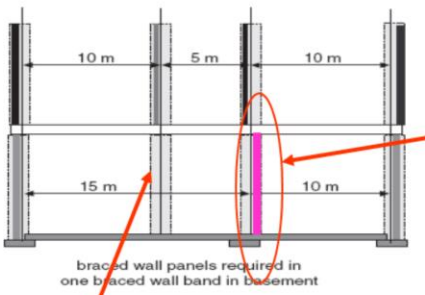


braced wall panels required in braced wall band in basement

30

There is a relaxation to the maximum distance between braced wall bands for basements. The spacing may be increased to 15 m, but braced wall panels that are strong walls must extend through to the basement.

Relaxation of Bracing Requirement (1) – Basement and Crawl Space



Cannot be omitted since braced wall panel above is a 'strong' panel

Can be omitted since braced wall panel above is not a 'strong' panel and within 15 m there is a 'strong' panel

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This example better illustrates which braced wall panels must be carried through to the basement.

Because the right interior wall is a strong wall, it must be carried through to the basement and the designer cannot eliminate it and keep the wall to the left of it in lieu.

Relaxation of Bracing Requirement (2) – Porches

- Do not apply to perimeter of a single open or enclosed space
  - e.g. porches not projecting more than 3.5 m from building and not supporting a floor above

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There is an exemption from the braced wall band requirements for portions of the structure that project no more than 3.5 m from the building and that do not support a floor. Examples of these types of spaces are porches and sunrooms.

Relaxation of Bracing Requirement (3) – Garages

- Exemption for detached garages
- Exemption for front wall of attached garage serving single dwelling unit
  - Criteria for both is don't support floor
- Allow one large opening under certain conditions for attached garages
  - Adequate bracing on other 3 walls
  - Supporting no more than one floor above

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There are relaxation from the requirements for garages as follows:

Detached garages that don't support a floor are exempt.

The front wall of an attached garage serving a single dwelling unit and not supporting a floor is exempt.

For attached garages other than those just discussed, one large opening at the front is allowed if

- the maximum spacing between the front of the garage and the back wall of the garage does not exceed 7.6 m,
- there is not more than one floor above the garage,
- not less than 50% of the length of the back wall of the garage is constructed of braced wall panels, and
- not less than 25% of the length of the side walls is constructed of braced wall panels.

Specifications to Address Connections for Framing

- Tie roof trusses to wall framing for 1 in 50 yr HWP >0.8 kPa
- New nailing details – attach required braced wall panels to floor joists, rim joists or blocking, and to framing above and below
- Insert rim joist

Rim joist:
Outermost member in floor framing, other than blocking, be it parallel, perpendicular or on an angle to floor joists

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Other requirements relate to

- more stringent connection requirements for roof trusses to wall framing for wind
- new nailing details for connection of braced wall panels to floor joist, rim joists or blocking, and to the framing above and below

A new component, rim joist, has been defined as the outermost member in the floor framing, other than blocking, be it parallel, perpendicular or on an angle to the floor joists.

Specifications for Fastening of Sheathing to Framing

- Enhanced requirements for roof and wall sheathing in high wind and seismic
  - Longer fastener
  - Higher fastening density for roof sheathing within 1 m of roof edges

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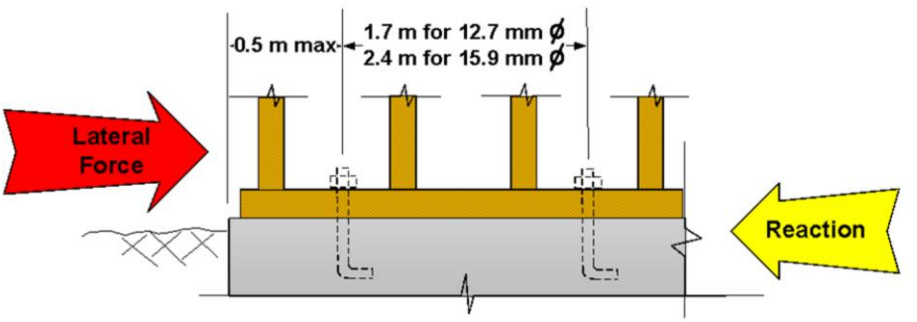
There are enhanced requirements for the connectors for roof and wall sheathing, for both the length of fastener and the number of fasteners. For roofs, this is a particular issue within 1 m of the roof edges where the localized wind uplift pressures are higher.

Specifications to Anchor Building to Foundation

- Enhanced anchor bolt detailing for high wind and seismic and more than one storey



36

There are more stringent requirements for anchorage to the foundation. There must be an anchor bolt no more than 0.5 m from the edge of the foundation wall. The maximum spacing of 12.7 mm diameter anchor bolts is 1.7 m, and the maximum spacing for 15.9 mm diameter anchor bolts is 2.4 m.

Other Changes

- Modify "Support of Walls" where braced wall panels are required
- Modify "Bracing and Lateral Support" to prevent buckling of stud when unfinished interior wall → blocking/strapping

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Because braced wall panels are a critical component of the lateral force resisting system, they must be adequately supported and they must be adequately braced to prevent buckling. Existing provisions have been modified to account for this.

This ends the portion of the presentation dealing with the basic prescriptive requirements for lateral loads in Part 9.

Part 9 Lateral Loads

- General Background
- Technical Principles
- Summary of Basic Code Change Proposals
- Trade-Off Code Change Proposals

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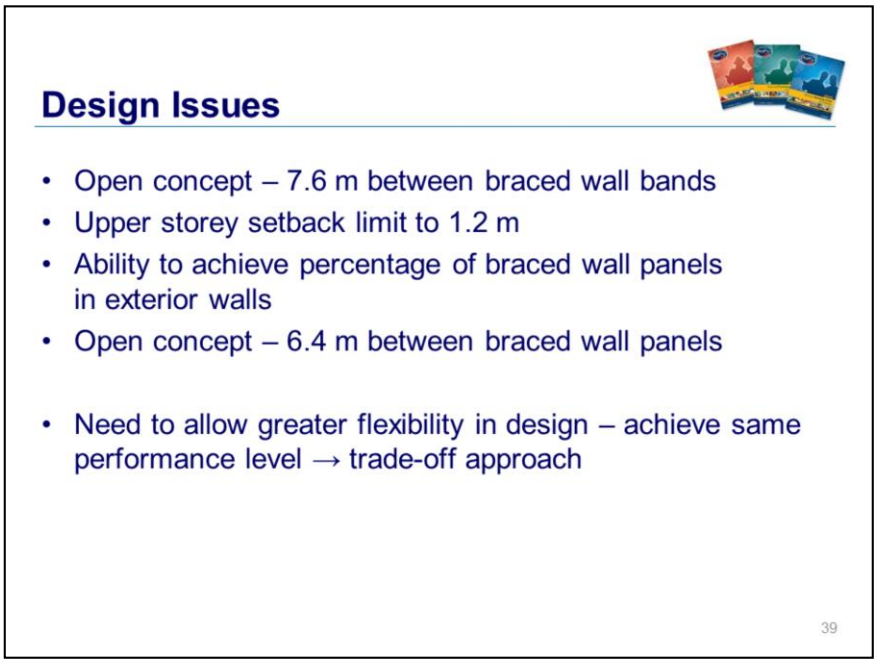
Now, we will look at what we term the trade-off provisions.



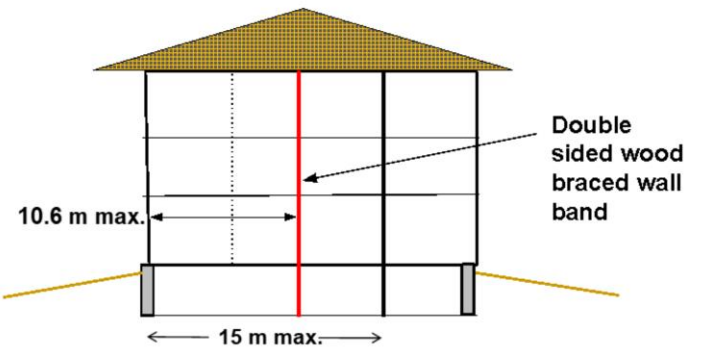
Stakeholders contributed that the basic provisions placed many restrictions on design and layout due to the spacing and size limitation of the braced wall bands and braced wall panels. They requested flexibility in the approach to account for

- a larger spacing between centre lines of the braced wall bands than the prescribed 7.6 m for certain locations, which falls under the trend to open concept
- upper storey setbacks of 1.2 m, which in some areas are mandated by local by-laws
- larger windows and doors in one first storey wall in each direction, and
- a larger spacing than 6.4 m between the ends of braced wall panels, which falls under the trend to open concept

In order to allow for this flexibility, trade-off proposals were developed that allow reduced performance levels for some components by requiring stricter construction for others to compensate, and thus achieve the same overall performance level.

Flexible Design – Trade-Off Provisions

- Open concept – 7.6 m between braced wall bands
- Can increase spacing of braced wall bands from 7.6 m up to 10.6 m
  - Braced wall band is "strong wall"



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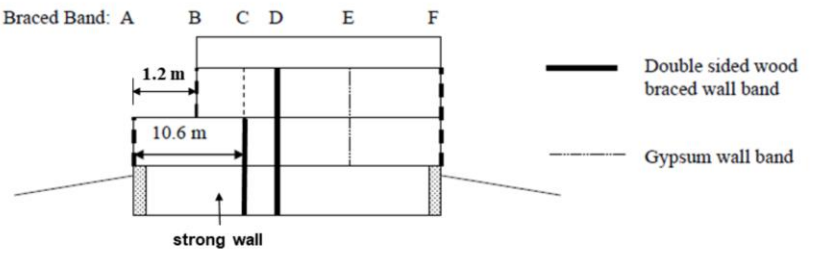
The 7.6 m maximum spacing between centre lines of braced wall bands can be increased to no more than 10.6 m under the following limits:

- the wall whose spacing is being increased is constructed as a strong wall
- this wall extend to the basement
- this wall not be accounted for when considering the maximum 15 m spacing between strong walls.

Flexible Design – Trade-Off Provisions – Cont'd

- Upper storey setback limit to 1.2 m
- One exterior upper storey wall in each orthogonal direction can be set back provided
  - Is a "strong wall" below, within 10.6 m of exterior wall
  - Floor supporting setback is sheathed with wood-based
  - Reinforced connection to exterior perpendicular walls



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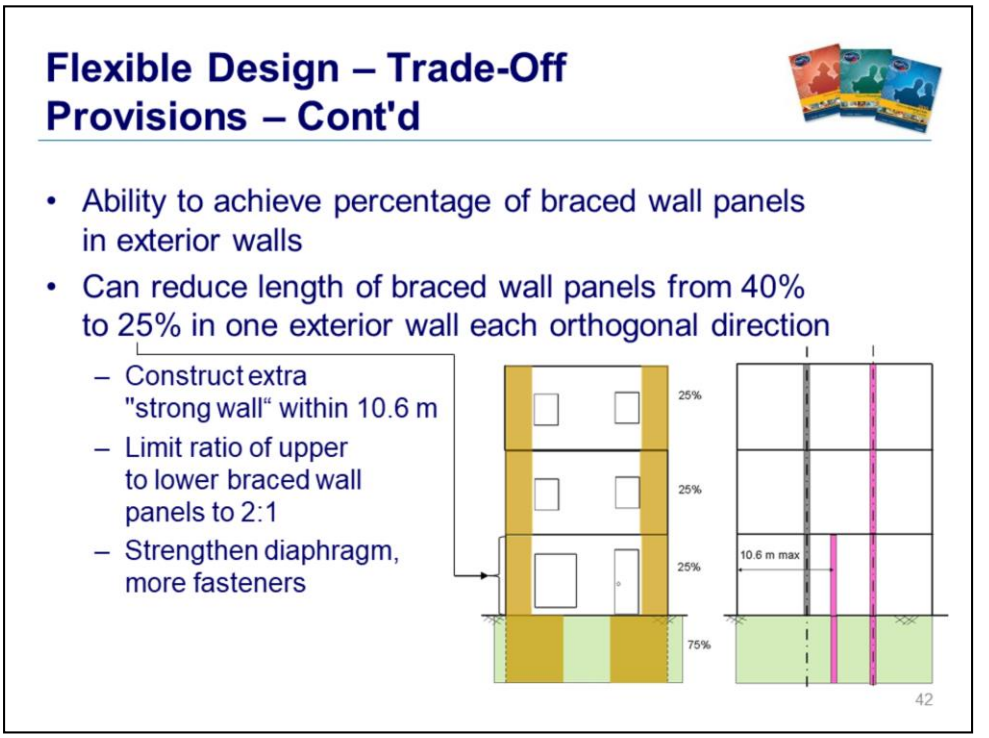
One exterior upper storey wall in each orthogonal direction can be setback a maximum of 1.2 m provided:

- the adjacent interior braced wall band is no more than 10.6 m from the exterior wall
- it is constructed as a strong wall
- it extends to the basement
- it is not accounted for when considering the maximum 15 m spacing between strong walls



The 40% amount of braced wall panel in the first storey exterior wall can be reduced to 25% for one wall in each orthogonal direction if

- an additional interior braced wall band that is no more than 10.6 m from the exterior wall is constructed
- it is constructed as a strong wall
- it extends to the basement
- it is not accounted for when considering the maximum 15 m spacing between strong walls
- the ratio of braced wall panels in the upper storeys to the first storey does not exceed 2 to 1 so as not to create a soft storey

There are also requirements to strengthen the horizontal diaphragm and to have more fasteners.

Flexible Design – Trade-Off Provisions – Cont'd

- Open concept – 6.4 m between braced wall panels
- Can increase spacing between braced wall panels to 7.3 m
  - Minimum length of braced wall panel increased to 1.2 m

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The maximum 6.4 m spacing between braced wall panels in a braced wall band can be increased to 7.3 m provided the minimum length of braced wall panel in that band is increased from 750 mm to 1200 mm.

Each of the trade-off provisions described is mutually exclusive.

This concludes the presentation on the new lateral load provisions for NBC Part 9. Please e-mail any questions you may have to …